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APPLICATION NUMBER: 60/526,613


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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)					
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<input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto					
TITLE OF THE INVENTION (280 characters max)					
VERY HIGH POWER PULSED FIBER LASER					
Direct all correspondence to: CORRESPONDENCE ADDRESS					
<input checked="" type="checkbox"/> Customer Number		22902		 22902 CLARK & BRODY	
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ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/>	Specification	Number of Pages	4	<input type="checkbox"/>	CD(s), Number
<input type="checkbox"/>	Drawing(s)	Number of Sheets		<input type="checkbox"/>	Other (specify)
<input type="checkbox"/>	Application Data Sheet. See 37 CFR 1.76				
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)					
<input checked="" type="checkbox"/>	Applicant claims small entity status. See 37 CFR 1.27.				FILING FEE AMOUNT (\$) \$80.00
<input checked="" type="checkbox"/>	A check or money order is enclosed to cover the filing fees				
<input checked="" type="checkbox"/>	The Director is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number 50-1088				
<input type="checkbox"/>	Payment by credit card. Form PTO-2038 is attached.				
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
<input checked="" type="checkbox"/>	No.				
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Respectfully submitted,

SIGNATURE

TYPED or PRINTED NAME

TELEPHONE

CONRAD J. CLARK

202-835-1111

Date

12/04/2003

REGISTRATION NO.

(if appropriate)

Docket Number:

30,340

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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

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P19SMALL/REV05

VERY HIGH POWER PULSED FIBER LASER

Increase in the power of a near diffraction-limited CW beam generated from Yb-doped fiber lasers constitutes an important advancement, because this fiber technology is uniquely efficient (20% to 40% plug-to-optical conversion) and promises to lead to completely integrated lasers. Achieving high pulse energies with pulsed fiber lasers is a much more formidable problem, whose successful solution could lead to a breakthrough in a number of practically important applications. Difficulty in scaling pulse energies arises from the limited size of the fiber core and the relatively long pulse propagation length necessary to achieve high gain. High peak powers within fiber based amplifier systems are further limited by non-linear phenomena within the fiber. Increasing the size of the core appears to be one of the main directions of the technological advancement towards higher energies. This scaling, however, can eventually lead to highly multimode core and, consequently, to significant degradation of the beam quality.

The present invention relates to the generation of greater than 27-mJ, 50-ns pulses, which represents a 350% improvement over the highest previously achieved energy. Another aspect of the invention is that the mode quality of a highly multimode large core fiber can be significantly improved by using the mode-filtering effect of a coiled, low-NA core. The invention uses a coiled fiber of 200- μm diameter and 0.06 NA core, which supports ~ 200 transversal modes, to produce an output beam with $M^2 = 6.5$, thus effectively reducing number of modes at the output of the fiber to ≤ 20 modes.

The arrangement comprises an all-fiber system seeded with an electric-pulse-driven, single-longitudinal-mode diode laser emitting at 1064 nm. This arrangement allows for a very high power, pulsed, and frequency tunable laser source from 1030 nm to 1085 nm. Such seeding enables control of both the shape of the seed pulse and its repetition rate, which is selectable by

the electric-pulse generator in the range from a single-shot to 1 MHz. The 10 - 30 nJ seed pulses produced by this arrangement were first amplified in a single-mode, core-pumped Yb-doped fiber pre-amplifier, having standard optical components and pumped with telecom-grade 980-nm single-mode diodes. For pulse repetition rates in the range from 10 Hz to 1 kHz, up to 38- μ J has been obtained in the preamplifier stage. These pulses were further launched into a cladding-pumped 50- μ m diameter core Yb-doped fiber amplifier, and produced up to 2.7 mJ per pulse. An important feature of this multistage system is that acousto-optic gates are not required between the stages of a single-mode pre-amplifier, a 50- μ m core amplifier, and the final power amplifier. Isolation from ASE is achieved by the use of narrow bandpass filters at 1064 nm, which suppress 1039-nm peak ASE emission between the stages.

The final power amplifier stage is based on a large core, double-clad 3 – 4 m long Yb-doped fiber with 200- μ m diameter, 0.06 NA core, and 600- μ m diameter, 0.45 NA inner pump cladding. The amplifier was end-pumped with a variable power (maximum 200W), 915-nm diode laser. Amplified pulse energy at the repetition rate of 100 Hz as a function of seed energy is shown in Fig. 1. This figure shows agreement with the predicted saturation performance according to the Frantz-Nodvick model. Estimated saturation fluence value for the 200- μ m core fiber is ~ 21 mJ, which indicates that much larger pulse energies can potentially be extracted. The measured temporal profile of the 50-ns long pulses is presented in Fig. 2. For very long duration pulses (> 300 μ s) total pulse energies of up to 82 mJ have been obtained. At these durations, however, it is likely that the energy extraction is not limited by the saturation fluence but rather by the saturation power of the amplifier. For a coiling radius of 15 cm, the higher-order mode filtering effect was very strong, resulting in the output beam of $M^2 = 6.5$. Our numerical model accurately predicted this amplified beam quality. However, the fiber coiling

and associated beam improvement also produced gain reduction (losses in the fiber) of $\sim 6\text{dB}$ due to the continuous diffusion-like transfer from lower-order modes to higher-order fiber modes and the subsequent radiation of the beam power into the cladding. This gain reduction was measured experimentally and also predicted using the numerical model.

It will be appreciated that the invention provides nanosecond pulse energies in the tens of millijoules range with very large core fibers. Large core dimensions ensure significant extractable pulse energies as well as increased susceptibility to detrimental nonlinear and bulk damage effects. Mode quality can be significantly improved by using coiled, low NA fibers to ensure loss for higher order transversal modes.

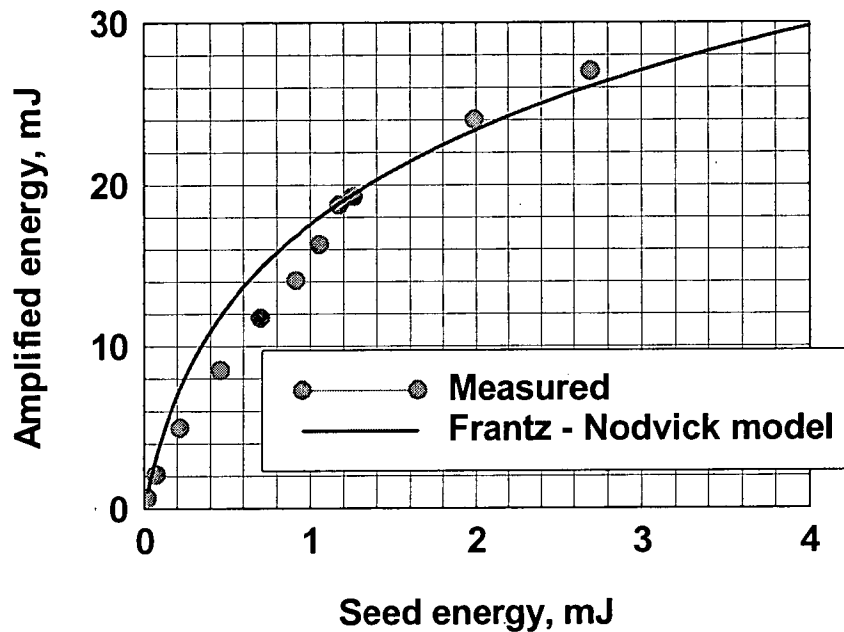


Fig. 1. Measured amplified pulse energy as a function of the seed energy. Solid line – prediction according to the Frantz – Nodvick model.

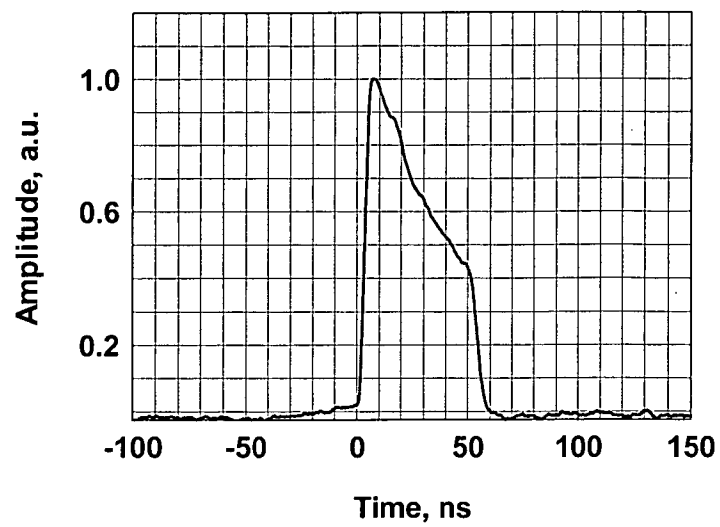


Fig. 2. Temporal profile of amplified pulses.